



## **MESSENGER Magnetic Field Observations of Upstream Ultra-Low Frequency Waves at Mercury**

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The region upstream from a planetary bow shock is a natural plasma laboratory containing a variety of wave particle phenomena. The study of foreshocks other than the Earth's is important for extending our understanding of collisionless shocks and foreshock physics since the bow shock strength varies with heliocentric distance from the Sun, and the sizes of the bow shocks are different at different planets. The Mercury's bow shock is unique in our solar system as it is produced by low Mach number solar wind blowing over a small magnetized body with a predominately radial interplanetary magnetic field. Previous observations of Mercury upstream ultra-low frequency (ULF) waves came exclusively from two Mercury flybys of Mariner 10. The MESSENGER orbiter data enable us to study of upstream waves in the Mercury's foreshock in depth. This paper reports an overview of upstream ULF waves in the Mercury's foreshock using high-time resolution magnetic field data, 20 samples per second, from the MESSENGER spacecraft. The most common foreshock waves have frequencies near 2 Hz, with properties similar to the 1-Hz waves in the Earth's foreshock. They are present in both the flyby data and in every orbit of the orbital data we have surveyed. The most common wave phenomenon in the Earth's foreshock is the large-amplitude 30-s waves, but similar waves at Mercury have frequencies at near 0.1 Hz and occur only sporadically with short durations (a few wave cycles). Superposed on the "30-s" waves, there are spectral peaks at near 0.6 Hz, not reported previously in Mariner 10 data. We will discuss wave properties and their occurrence characteristics in this paper.